general by a chemical method is greatly to be desired. The spectrum of chlorophyll solution shows definite absorption bands in the red and orange and almost general absorption in the blue, indigo, and violet with smaller bands interspersed in other portions. The projection of the solar spectrum for some hours upon a leaf has demonstrated that photosynthesis takes place most prominently in the region of the red and to some extent at other points, though few acceptable results indicating the effect of light of various wave lengths upon other life processes of the plant have been stated.[5] As far as light is concerned physiological investigations deal, in the main, with that factor in its totality, its effect upon plants being generally regarded as photochemical; hence, the feasibility of the chemical method of measurement herein described, should future investigations confirm its seeming usefulness.

Some of the probable advantages of the method are the ease and low cost with which it may be operated, the avoidance of complicated, costly and frequently unreliable mechanisms, and the reduction of error due to the personal factor in observation, so prominent in the photographic paper method. The chief values of the chemical photometer, however, if its reliability is established, will lie in the facility with which several exposures may be be made simultaneously under various degrees of illumination and the fact that the solution gives an automatic integration for the time period of exposure. The automatic exposure of vessels containing light sensitive solutions by the use of clocks has been accomplished by Stone[6] and a similar arrangement may be advantageous in connection with the one just described. Though plans are made for further work with the oxalic-acid-uranium-salt photometer during the coming growing season, it is hoped that it will be carefully investigated in its application to problems in plant physiology, especially with reference to the correlation of its properties with the various life processes, since such research, though attractive, lies without the province of the writer in his present field of activity.

FURTHER STUDY OF HALOS IN RELATION TO WEATHER.

By HOWARD H. MARTIN, Observer.

[Dated: Weather Bureau, Columbus, Ohio, March 4, 1918.]

Since 1907 several papers have been prepared on the subject, based on data from isolated stations, and it is the desire of the writer to present herewith, in conjunction with the results obtained at Columbus, Ohio, the collected results of all observations over the United States and to show the possible relation between these results and latitude, longitude, and the average cyclonic tracks.

Blue Hill, Mass. Blue Hill Observatory.

Lat., 42° 21′ N.; Long., 71° 4′ W. (approximate).

Number of observations, 569, of which 467 were solar and 102 were lunar. Month of greatest frequency: solar halos, average 5.9 in March; lunar halos, average, 2.7 in January. Month of least frequency, solar, average 2.3 in October; lunar, 0.4 in July.

Wauseon, Ohio. Thomas Mikesell, observer.

Lat., 40° N.; Long., 84° W.

Length of record, 1873–1912, inclusive. Total number of halos observed, 2,918, of which 2,219 were solar and 699 were lunar. Month of greatest frequency, April, average 9.2; least, August, average 3.2.

Fort Worth, Tex. Weather Bureau.

Lat., 32° 43′ N.; Long., 97° 15′ W.

Length of record, 1910-1915, inclusive. Total number observed 170, of which 86 were solar and 84 were lunar. Month of greatest frequency, January, average 4.0; month of least frequency, September, 0.3.

York, N. Y. Milroy N. Stewart, observer.

Lat., 42° 52′ N.; Long., 77° 53′ W.

Total number of halos observed 372, of which 317 were solar and 55 lunar. Month of greatest frequency, March, average 3.4; least, June, average 2.1.

Lake Montebello, Md. Martin L. Dobler, observer.

Approximate lat., 39° N.; Long., 76° W.

Total number of 17 observed from November 5, 1905 to December 26, 1906, of which number 9 were solar and 8 lunar.

Columbia, Mo. Weather Bureau.

Lat., 38° 57′ N.; Long., 92° 20′ W.

The period of observation was approximately two years, during which time 40 halos were observed, of which number 37 were solar and 3 were lunar. The month of greatest frequency was January, least, July and August.

Columbus, Ohio. Weather Bureau.

Lat., 39° 58′ N.; Long., 83° 0′ W.

Period of observations extends from January 1, 1906 to December 31, 1917, during which time 185 were observed, of which 83 were solar and 102 lunar. Month of greatest frequency, April, 2.4; least, August, 0.2.

The record at Columbus, Ohio, in point of numbers observed, is not as complete, apparently, as it might be, but this is largely due to the generally smoky condition of the atmosphere. In Table 1, showing the general relation to precipitation of halos at this station, no attempt is made to discriminate between the solar and the lunar, sparsity of observations prohibiting. A striking similarity may be noted in the record at this station and the record of Wauseon, Ohio, of the months of greatest and least frequency. During the 12 years record at Columbus, but one halo was observed during the month of August.

TABLE 1.—*Relation existing between halos and subsequent precipitation, at Columbus, Ohio, 1906–1917, inclusive.*

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Number considered	16	20	24	35	18	7	4	1	5	12	17	18	*181
Per cent followed by precipitation—													
In 18 hours	50	25	46	63	77	28	50	100	60	42	53	50	54
In 24 hours	69	40	58	74	77	43	75	100	60	59	60	67	65
In 36 hours	81	60	65	80	83	57	75	100	100	67	65	72	75
In 48 hours	94	65	75	88	89	71	100	100	100	75	82	88	86
Not followed within 60 hours	6	30	17	11	11	14	0	0	0	17	12	6	8
Average interval between halo and precipitation	[illegible]	44.4	33.4	24.6	17.2	40.3	[illegible]	11.4	16.9	28.2	29.7	24.3	26.2
Average duration of halo	1.9	2.4	1.7	1.6	1.4	[illegible]	2.5	2.5	1.6	1.3	1.6	1.5	1.8

* Four halos not considered because of incomplete data.

Table 2 shows all stations arranged according to latitude and longitude, and presents the relative value of the halo as a rain forecast for the several localities. There are indications of a possible maximum percentage of verifications in the higher latitudes, increasing as the longitude decreases.

[5] *Richter, A.* (in Rev. Gen. de Bot., 1902, p. 212) indicates that the amount of photosynthesis in a leaf subjected to monochromatic light, is a function of the heat energy of that light and independent of its wave-length. Recent articles published by Dr. S. O. Mast in the Journal of Experimental Zoology, deal with the stimulating effect of different spectral colors on lower organisms. The bactericidal action of ultra-violet rays, which must be a function of wave length rather than heat, is well established (Ayers, see footnote 4).

[6] *Stone, G. E.* Relation of light to greenhouse culture. Mass. Agri. Expt. Sta. Bull. 144, July, 1913. (Though the results of measurements of light by a photochemical method are stated, the details of the method are not given.)

TABLE 2.—*Percentages of verification in halo-rain forecasts for stations, arranged according to latitude and longitude.*

Station.	Longitude.	Latitude.	24-hour.	36-hour.	48-hour.	60-hour.	Average interval.
	° W.	° N.					
Fort Worth, Tex.	97	34	36	48	59	68	24.1
Columbia, Mo.	92	39	24	......	49	59	......
Wauseon, Ohio	84	42	58	......	......	......	......
Columbus, Ohio	83	40	65	75	86	92	26.2
York, N. Y.	78	43	64	......	83	......	17.3
Lake Montebello, Md.	76	39	11	......	67	......	......
Blue Hill, Mass.	71	42	......	68	......	......	15.6

While there is an increase of percentages of verification eastward to approximately longitude 80° West, there is also an appreciable falling off as the Atlantic coast is approached. With this in mind, reference to a map of storm tracks (e. g. supplement 1, chart 1) would indicate that the percentages of verification will increase, not so much with latitude or longitude but with the proximity of the observation point to one or more of the storm tracks. The chart showing the weighted, or average cyclonic tracks for January will apply to the months of greatest frequency as well, especially in the northern districts. It will be noted that the eastern stations lie between the paths, or upon the common path of practically all the storms that cross the United States and that Fort Worth, Tex., and Columbia, Mo., are far south of the tracks of the more frequent types. A large percentage of the precipitation occurring over these districts is due to cyclones of either the South Pacific or Texas type, relatively infrequent.

As outlined in previous papers, it has been found at Columbia, Mo., that "22-degree circles are followed by precipitation within 12 to 18 hours, the storm crossing the meridian near the point of observation; (2), when the 45-degree circle is observed, the storm center is usually from 800 to 1,000 miles away and precedes precipitation, if any, by 24 to 36 hours." These deductions were based on the consideration of a relatively small number of observations.

The larger percentage of LOWS affecting the weather at Fort Worth, Tex., pass far to the northward of that station. It was found that quite frequently during the winter months, the center remained so far north as to leave the sky veiled with cirrus and cirro-stratus for from 24 to 48 hours at a time. In cases of this kind, halos occurred slightly in advance of the wind-shift line and were fairly good prognosticators of advancing cold. They were usually followed by "northers" within 24 hours and rarely by precipitation.

At Wauseon, Ohio, a relation was determined between the percentage of verification and the atmospheric pressure. Kirk found that with the pressure below normal and falling, 83 per cent of observed halos were followed by precipitation within 24 hours; that, with the barometer low, but rising, but 53 per cent were followed by rainfall within the prescribed period, and that with the pressure above normal and rising, 63 per cent were followed by fair weather.

A marked relation must, of course, exist between the verification of the halo forecast and the prevailing direction of the wind, the probability of rain increasing with the change to the quarter most often accompanied by precipitation. Thus, at Fort Worth, it was found that 94 of the 99 halos followed by rain or snow within 48 hours were attended or followed by easterly winds and falling pressure. Of the 94 halos so observed, 82, or 87 per cent, were followed by precipitation by the end of the succeeding day. Like conditions appear to exist at Wauseon, Ohio, with southerly winds, and at York, N. Y., with southwest winds. At Columbus, 88 per cent of the halos preceding precipitation by 48 hours were accompanied or followed by southwest winds.

So, with all these facts well in mind, it must be said that the halo indicates the approach of precipitation only in so far as it heralds the approach of the cyclone. To only the extent that the passage of the cyclone affects the weather at the station, is the halo reliable. With knowledge of the condition of the barometer, whether rising or falling, and knowing which direction of the wind most often precedes precipitation, the layman may know what degree of faith to place in the celestial harbingers; but, without this knowledge, he will often have occasion to fall back upon the old adage, "All signs fail in fair weather." The halo is a faithful detector of cyclonic presence; the pressure and wind indicate the cyclone's approach and passage, and a just consideration of these three elements will go far to establish the halo, not as a promise of rain or storm, but as a warning that somewhere far to westward a cyclone is advancing. In this point alone the halo excels.

SELECTED BIBLIOGRAPHY.

The following list of recent papers is selected from those published by the Weather Bureau since 1897:

(1) Types of storms in the United States and their average movements, by Edward H. Bowie and R. Hanson Weightman. Monthly Weather Review Supplement No. 1, Weather Bureau Publication No. 538.
(2) Storms, storm tracks, and weather forecasting, by Frank H. Bigelow, Washington, 1897. 87 p. 8°. (U. S. Weather Bull. 20, W. B. Pub. No. 114.)
(3) Halos and their relation to the weather, by A. H. Palmer. 6 p. Monthly Weather Review, Washington. 42: 446.
(4) Halos and precipitation at Wauseon, Ohio, by J. M. Kirk. Washington, Monthly Weather Review. 42: 616.
(5) Halos at Fort Worth, Tex., and their relation to the occurrence of subsequent precipitation, by Howard H. Martin. Washington, Monthly Weather Review. 42: 67.
(6) Observations of halos and coronas in England, by M. E. T. Gheury. Washington, Monthly Weather Review. 35: 213-215.
(7) Observations of halos at Columbia, Mo., by George Reeder. Washington, Monthly Weather Review. 35: 212.
(8) Halo observations at York, N. Y., by Milroy N. Stewart. Washington, Monthly Weather Review. 43: 441.
(9) Halos and rain or snow, by Martin L. Dobler. Washington, Monthly Weather Review. 35: 227.

REMARKABLE HALO OBSERVED AT NASHVILLE, TENN., MARCH 16, 1918.

By R. M. WILLIAMSON, Meteorologist.

[Dated: Weather Bureau, Nashville, Tenn., Mar. 20, 1918.]

An interesting and unusual form of solar halo was observed at this station on March 16. It was first seen as a faint fragment of the usual 22-degree circle at 8:45 a. m. (90th meridian time). An hour or more later it appeared as a complete circle, though ill-defined and presenting no unusual features. At 11:45 a. m. the attention of the station force was called to a remarkable series of rings about the sun, and the coloring and arrangement of the circles were so distinct as to attract wide attention. The phenomenon continued, although in changing form, until about 5:30 p. m.

Unfortunately, no instruments were available with which to determine angular distances, but a comparison of this halo with figures outlined in Besson's "Different Forms of Halos" leaves little doubt as to the correctness